

coil valve V-1. This serves as a low limit for the fan discharge temperature during heating operation. When V-1 is closed, thermostat T-1 then gradually opens maximum outdoor-air damper D-2 and closes return-air damper D-5 proportionately. At 55 F outdoor temperature, D-2 is wide open and D-5 is closed. Exhaust-air damper D-4 opens and closes in synchronization with D-2. At about 70 F outdoor temperature when the outdoor air is no longer useful for natural cooling, T-2 closes D-2 and D-4 and opens D-3.

Reheater coil valve V-3 is controlled by submaster thermostat T-3 in the fan discharge. This thermostat is automatically readjusted over an appropriate range of temperature by thermostat T-4 so that the discharge temperature matches the space requirements. When the space temperature tends to rise above a predetermined value, T-3 has already been readjusted downward far enough to keep reheater valve V-3 closed. T-4 then controls cooling coil valve V-2 directly, to maintain the desired space temperature.

Humidistat H operates humidifier valve V-4 to maintain the desired humidity in the conditioned space. It is usually adjusted to maintain 30 to 40 percent relative humidity, and therefore keeps the humidifier off during cooling operation when the humidity is higher.

TEMPERATURE CONTROL IN HOT WATER SYSTEMS

Hot water heating systems permit use of relatively simple automatic temperature control for the purpose of reducing operating costs and providing comfortable temperatures. On installations not requiring different supply-water temperatures simultaneously, and where the boiler is not used to heat domestic hot water, outdoor reset control of the supply-water temperature may be obtained by direct control of the burner from a thermostat that is located in the boiler water and is reset in accordance with outdoor temperatures. Separate high limit and low limit controls should be provided.

In systems using converters for a hot water supply, a controlling thermostat actuated by the leaving water temperature modulates the heat source to the converter. The set point of this supply-water thermostat can be readjusted in accordance with outdoor temperature.

In some systems, a boiler or converter supplies water at a constant temperature, and three-way mixing valves are used to supply water at different temperatures for various uses or to multiple zones. In these cases, a three-way mixing valve, under control of a thermostat in the valve discharge, blends boiler water with return water to provide supply water at the desired temperature. The control setting of this thermostat in the valve discharge can be reset in accordance with outdoor temperatures.

On systems using outdoor-reset supply water and lowered night or week-end temperatures, provision should be made for warmup on restoration to day or normal operation. This can be accomplished by a program control, a warmup space thermostat, or some similar means of providing higher than normal water temperatures during the warmup period.

A measure of control can also be accomplished by use of a room thermostat to operate the burner. This type of control is applicable only to residences or very small commercial installations, where there is no great difference in heating requirement throughout the building. Where a difference in heating requirements throughout the building does exist, it is advisable to control the supply-water temperature with provision for automatic control or manual adjustment of heating unit output in individual spaces.

Economical zone control can be obtained by separate return or supply piping for zones, with a zone thermostat to operate zone pumps or automatic valves. The piping for each zone should be isolated to avoid a common return line, because, in many cases, the return water from one zone is warmer than required for the supply water to another zone.

The control of air-handling units in a hot water heating system requires careful consideration. Where the piping required is within economic limits, it is advisable to use a three-way mixing valve and a pump in the coil circuit (see Fig. 8, Chapter 11 of the 1964 GUIDE AND DATA BOOK). This arrangement provides a constant flow to the coil while the temperature of the water to the coil is varied by changing the mixture of supply water and return water. If it is impracticable to use separate three-way valves and pumps for each coil, it is necessary, when varying the flow to a hot water coil, to use control valves with plugs or discs designed for close control of flow. They should also be accurately sized for the flow required by the coil at a pressure drop as large as the pump and the piping system will permit. Face and bypass dampers to vary the flow of air over a coil with constant water flow can be used in the control of air-handling units.

Precautions should be taken to prevent the freezing of water in a hot water heating system whenever design outdoor temperatures are lower than approximately 20 F, particularly if the system is to be operated on an intermittent basis as in schools where normal operation is not required on Saturdays or Sundays or during vacation periods. In selecting a means of freeze protection, consideration should be given to the type of system as well as outdoor temperature. For instance, an air-handling unit to heat outdoor air must have the coil protected for 32 F, whereas supply mains and radiation usually are not subjected to freezing temperatures until the outdoor temperature drops considerably below 32 F for extended periods. Intake dampers on air-handling units that heat outdoor air should be interlocked with the fan motor, so as to close whenever the fan is not running. Provision should be made to either close the outdoor-air intake, stop fan operation, or both; if the water circulating in the coil drops below a safe temperature level. The possibility of water freezing in the mains can be minimized by using an outdoor thermostat to provide continuous circulation of the water whenever the outdoor temperature drops below approximately 30 F. Another arrangement uses an interval timer and outdoor thermostat to provide intermittent cycling of the circulating pump whenever the outdoor temperature drops below some predetermined temperature. A thermostat in the return water at the boiler can be used to start the burner or other heat source if the temperature of the return water drops to about 40 F.

ZONE CONTROL OF STEAM AND WATER SYSTEMS

This section is concerned with zone controls for steam or hot water heating systems. Refer to Part II of this chapter for a general discussion of zoning.

Most zone control systems are designed to supply heat to a zone at a rate equal to the heat loss. This rate of heat input may be established by room thermostats, by controllers responsive to outdoor conditions, or by a combination of both. The outdoor controller responds to temperature and may respond to solar radiation and wind velocity and direction. Features which may be added to the basic zone control system include:

1. Means for automatically or manually varying the heat input to the zone to compensate for variations in internal heat gain. The automatic arrangement requires a thermostat at a

Automatic Control

representative location within the zone. The manual arrangement usually consists of a conveniently located switch.

2. Means for maintaining a lowered economy temperature or completely shutting off the heat at night or at other times when the zone is unoccupied. This may be accomplished manually or by means of a clock.

3. An arrangement providing rapid warm-up following a period at the nonoccupancy temperature. During this warm-up period, full heat may be admitted to the system or the heat input may be controlled at a higher-than-normal rate. The warm-up may be accomplished by a manual switch or may be part of the clock program. A warm-up thermostat located within the zone may be arranged to terminate the warm-up period independently of the switch or clock when the zone approaches the desired occupancy temperature.

4. A manual switch to provide full heat or no heat independently of other controls and to permit manual selection of the various clock functions.

5. Means for shutting off the heat completely when the outdoor temperature reaches a point where heat is no longer needed.

6. A high-limit thermostat in the zone to shut off the heat completely when the zone becomes overheated.

Steam: Zone Distribution

In continuous-flow steam systems the quantity of steam supplied to the zone is varied in accordance with the demands of the control system. To obtain equalized distribution of the steam, metering orifices are generally required on the inlets to all radiators or convectors. Supplementary controls for low heat output are often desirable. The following two arrangements are common:

1. Varying the difference in pressure between the supply and return which results in partially filling the heating units in accordance with demand. This method can be used on atmospheric or vacuum return systems.
2. Varying the pressure in the system while maintaining a constant differential pressure between the supply and return. This results in the heating units being filled with steam at a temperature which is proportional to demand. A vacuum pump maintaining a vacuum slightly below the supply pressure is required, and vacuums as high as 20 in. Hg during mild heating weather are common.

In intermittent systems, steam at full pressure is supplied intermittently to the zone, the length of the on and off periods being varied in accordance with the demands of the control system. Two common arrangements are:

1. A timing device controlled by an outdoor thermostatic element. This can be used to vary the on-off periods of boiler operation or the opening and closing of a steam valve as a function of outdoor temperature.
2. A control responding to an outdoor element and an element attached to a radiator or convector. This control varies the length and frequency of the on-off intervals in such a way that the radiator or convector temperature is varied in accordance with outdoor temperature.

For proper operation of zone control equipment, the heating system must be carefully designed and installed, and maintained in good operating condition. Vents, traps, vacuum pumps, and valves must be carefully inspected and repaired or replaced when required. Piping must be of adequate size, graded, and dripped. Return piping must be vented and any pockets or lifts must be removed.

Water: Zone Distribution

A common method of obtaining zone control of hot water systems consists of varying the temperature of water supplied to the zone inversely as the outdoor temperature varies. This may be accomplished by a submaster thermostat in the zone supply line, readjusted by an outdoor master thermostat, or by a single controller having one

measuring element in the supply line and another compensating element outdoors. On single-zone installations the controller may actuate the burner directly as shown in Fig. 32. If the boiler is also used for domestic hot water, the controls may be arranged as in Fig. 33. In this case, the boiler is controlled at a fixed temperature and the zone controller is arranged to operate a valve to proportion hot water from the boiler with cooler return water, to obtain the desired zone water temperature. On multiple-zone installations, the boiler is usually controlled at a fixed temperature, and each zone is controlled by a separate valve and outdoor compensated controller. Each zone should be equipped with a separate pump, because, in many cases, the return water from some zones is warmer than the required supply water for other zones. By using individual zone pumps, the designer can separate the returns and thus prevent overheating that would otherwise occur.

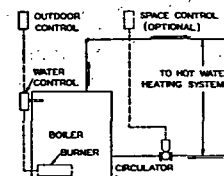


Fig. 32 Control of Hot Water Heating Without Domestic Hot Water Service

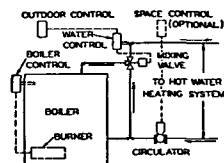


Fig. 33 Control of Hot Water Heating With Provisions for Domestic Water Heating

To compensate for variations in internal load, the action of the zone control may be modified by a room thermostat in each zone which either starts and stops the zone pump, modifies the relationship between outdoor temperature and water temperature, or operates an automatic valve in the zone supply or return line. Each zone may be further subdivided by providing a separate thermostat and valve for each subdivision.

Another zone control method for hot water systems consists of maintaining a constant water temperature and varying the volume of water supplied to the zone by means of a room thermostat which either starts and stops the zone pump or operates a two-position valve in the zone supply or return line.

Whenever flow control valves are employed in water circuits, it is necessary to employ a relief valve or pressure-regulating valve in a bypass connection around the pump.